

Technical proposals for the knowledge and the diffusion of the pollutant source: The artificial lighting

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Abstract:

The light pollution is a well known phenomenon for many years ago, but its cultural repercussion and diffusion has been small. The recent incorporation of minimization decisions in regional or state laws has facilitated its knowledge. In spite of it, it exists an important cultural resistance to its implant, and the reasons are usually the lack of a good formation of the light technicians and also the lack of awareness of the society with regard of the problematic.

From a technician point of view we can face the problem in different ways, it presents the following tools:

- R.A.M.A.-L.: evaluation methodology of the pollutant source magnitude (outdoor lighting). It bears in mind the system of illumination typology, implantation, environment of application and it has as result a quantitative value of the potential pollution in an installation.
- MATHEMATICAL MODEL FOR THE MEASUREMENT OF THE LIGHT POLLUTION. It proposes a theoretical model of the light pollution: across the results that the method R.A.M.A.-L. throws , it predicts the increase of brightness of the sky, depending on the characteristics of the environment (meteorological, orography), distance to the pollutant source ...
- E.I.A.L.: Method in development of Evaluation of the Environmental Impact of the Light in a specific environment.

From the slope of diffusion and knowledge, different routes of action are offered:

- Formation in degrees and masters: Courses of specialization and deepening of the problematic.
- Developing of doctoral thesis
- Incorporation of the study of the Light Pollution in studies of first and second degree of school with practical and active activities for them.
- Implementation of a web page for people between 12-18 years.

Key words:

Light pollution, project engineering, light environmental impact, educational, lighting assessment, light culture, sky glow, light at night

Text:

1. Context of the Phenomenon: Situation, evolution, knowledge.

Light Pollution is a type of affectation to the environment that takes place in areas of human activity during the night period. During the night they can be seen easily, the urban or populated areas, of the not populated areas.



Night view of Madrid: by Pablo Nespoli (ISS)

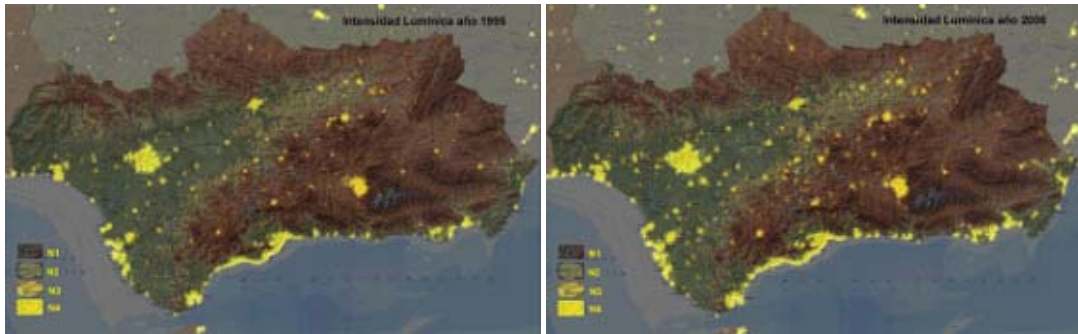
Or to differ between the most populated and rich territories, and the most dispersed or poor ones of the Earth (Xi Chen 2011).



Reconstruction of the night view of the Earth:

It had its origin in the last century, and the astronomers reached the voice in sign of alert, because of the difficulty that they found to study the sky at night (HOAG 1972) . But soon other repercussions were discovered in natural ecosystems (DOLSA 1998; BRUDERER 1999) , to the human being (TANNER 1991; PUKKALA 2006), to the increase in the air pollution ... (Stark 2010).

Its evolution has been important and remarkable.



Evolution of the light pollution in Andalusia from 1995 to 2004. Model treated across the images by satellite.. Source: Junta de Andalusia

And the affectation of the phenomenon can be very important, since it “travels” immediately, hundreds of kilometres:



View of Barcelona from dozens kilometres of distance.

A visualization of the problem is perceived but not a compression of it. It might be used the simile of the sensory perception:

“The light pollution can be looked but it cannot be seen ”.

So it has become part of our life, as a usual thing:



The light at night in the city. Source: EGG magazine

There is an important cultural resistance, that impedes its minimization; from the lighting and citizen point of view. These problems have been approached in two vectors of work:

- Technical Knowledge of the repercussions of the installations of system of illumination: tools for its quantification and assessment.
- To facilitate the access to information for the public in general and incorporation in studies of standard formation.

On it the following proposals are based:

2. *Technical Methods of quantification of the light pollution:*

a. *Method: R.A.M.A. – L.:*

R.A.M.A.-L. is Ratio and Analysis Light Environmental from Spanish Ratio y Análisis Medio Ambiental de la Luz.

The light pollution can be defined in different ways. From the most regular or technical point of view:

" The luminous night shining or light pollution is the luminosity produced in the night sky by the diffusion and reflection of the light in the gases, aerosols and particles in suspension in the atmosphere, proceeding, among other origins, of the installations of exterior system of illumination, well for the direct emission to the sky or reflected by illuminated surfaces ".

Source: R.D. 1890/2008. Regulation of Energy Efficiency in Instalations of Outdoor Lighting.

" ... the emission of light flow of the artificial night sources in unnecessary intensities, directions or spectral ranges for the accomplishment of the foreseen activities in the zone that the lights have been installed "

Source: Llei 6/2001. Protecció of the Medi Nocturn (Autonomous government of Catalonia).

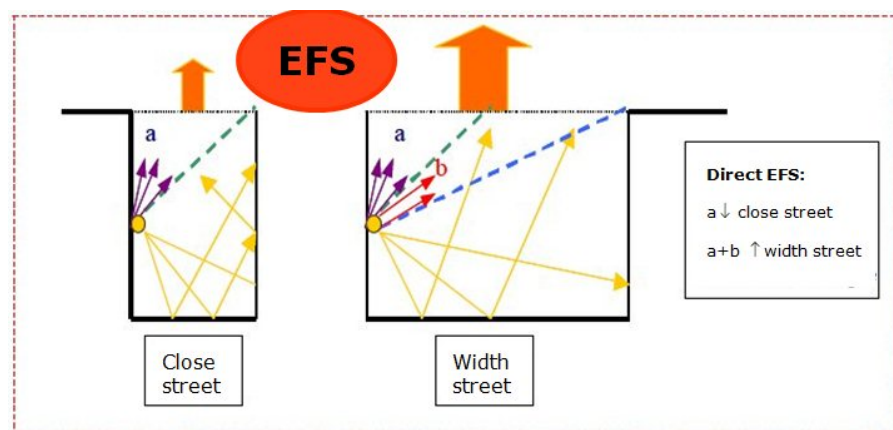
These definitions are based on the minimization of the repercussions of the phenomenon, but not to the environmental effects of the same one, as alteration of a natural environment. Therefore, a good designed installation of a system of illumination also will generate light pollution. A definition based on the effects, would be:

"Any adverse effect of artificial light including sky glow, glare, light trespass, light clutter, decreased visibility at night, and energy waste"

Source:DARKSKY.org

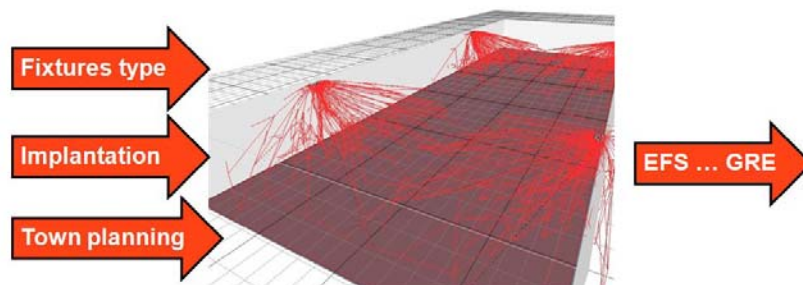
The method R.A.M.A.-L. (SAN MARTIN 2009; M. Garcia Gil 2010) starts with the premise that always contaminates with light, but, how much?. It is presented the characterization of the outdoor lighting in a specific environment (for example it bears in mind the urban development characteristics of a street, or the distance to a nature reserve ...), and evaluates the contribution of the system of illumination in study to his environment. It works in standard lighting software, modelling the real street or zone to assess. In the results they are evaluated by the following magnitudes:

E.F.S. (is Emission of the Superior Flux from Spanish: Emisión de Flujo Superior): Quantity of light lux (in lumens) that escapes to the sky and it is able to create sky glow. It bears in mind the disposition of the lights and the urban environment of implantation (width of the street, colour and height of the façades ...).



Different magnitude of the EFS with the same system of illumination and different urban environment of implantation

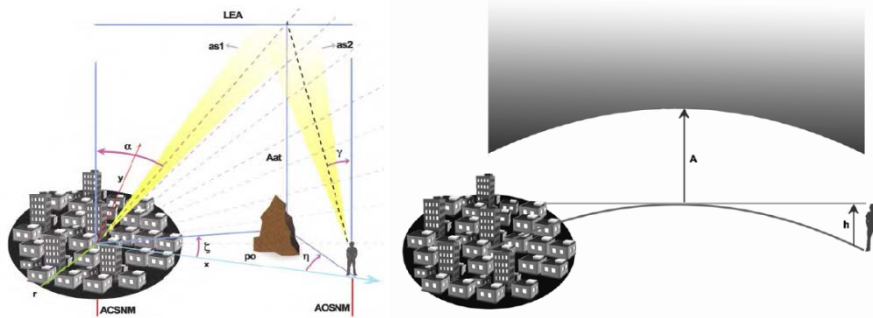
GRE (is Relative Magnitud of Emission from Spanish Grado Relativo de Emisión): Magnitude that quantifies the potential influence of the system of illumination, bearing in mind the quantity of luminous flux issued to the sky and its spectral distribution.



functional scheme of functioning of R.A.M.A. – L.

b. Measurement of the light pollution in natural spaces: offer of a predictive model

The repercussions of the system of illumination in real implantation on the environment, it is one of the darkest points in the problematic knowledge. The contribution of Dr. Héctor Solano Lamphar in the matter connected the characteristics of the pollutant focus with its effects increasing sky glow, bearing in mind the orographical interferences, distance, and meteorological conditions.



Scheme of the proposal where distances and angles are characterized. In the second figure the radius of Earth curvature influence (H. A. Solano Lamphar 2010)

Theoretical model evaluates the variation of night conditions of luminosity in spaces affected by the Light Pollution:

$$I = Fd \times AC \times CT \times PA^{-2} \left(e^{-\frac{h}{A}} \right) \times \frac{1}{4\pi} \left((Dm \text{prab} Dm \times Daprab Da) \right) as2V$$

where:

I = Light pollution coefficient

Fd = Directed flux

PA = Distance between city and effective limited height of atmosphere

$\left(e^{-\frac{h}{A}} \right)$ = Relation for curved earth geometry

as2 = Secondary solid angle

AC = City area

Proposed formula in mathematical model (H. A. Solano Lamphar 2010)

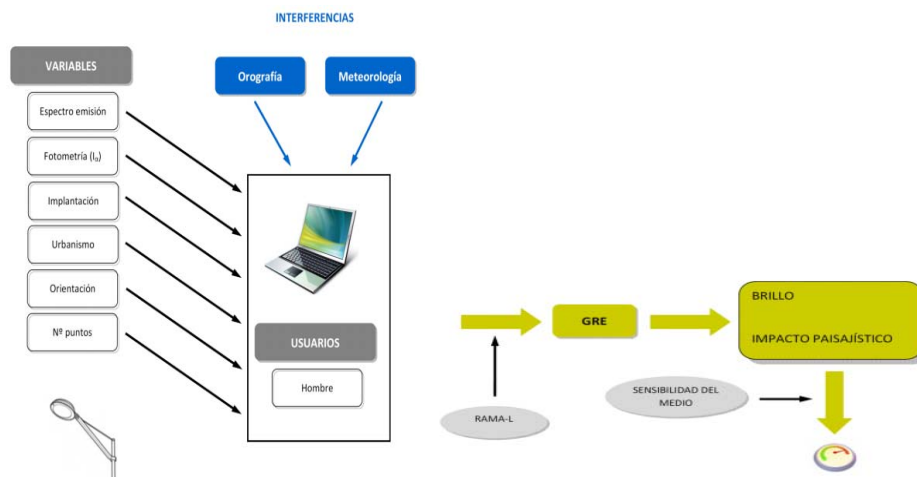
c. **G.E.I.A.L.:**

In English: Group of Environmental Light Impact Evaluation. In the engineering projects the evaluation of the environmental repercussions associated with the human activity is necessary. The lighting projects do not escape to this premise.

From the point of view of outdoor lighting projects a method of Evaluation of the Environmental Light Impact is developing.

In this method the affectation of the light is studied in 3 potentially affected environments: The sky at night, the natural night ecosystem and the human habitat. Each one with specific characteristics of sensibility depending on each project.

The method will allow the numerical rating of the influence of a system of lighting project in an environment, and it will allow the rating of different alternatives of design.



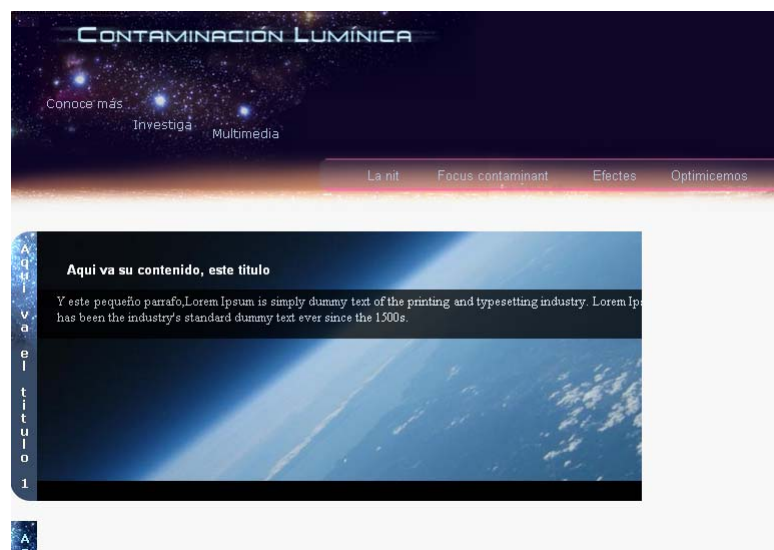
Example of the studies scheme of the affectation to the increase of natural night brightness. (M. Garcia Gil 2011)

3. *Proposal actions of diffusion and promotion of the knowledge*

a. *Incorporation and centralization of educational information about light pollution*

There is nowadays a lot of information about light pollution, especially in the network. This information is much dispersed and it comes from different sources and quality. For the knowledge of the problematic, overcoat orientated to young people, it is difficult to accede to the same web-site to be formed in this matter.

So it is proposed the following web page:



Home page. *"Contaminación Lumínica, la energía que quema la noche"*(*"Light pollution. The energy that burns the night"*)

This web page includes theoretical information about light pollution, but also includes experiences to approach it personal and independently: Tools, links to quantify the quality of the sky, illustrative videos, interactive tools, sources of social networks ...

b. *Diffusion in degrees studies.*

B.1 Doctoral Theses development related to the topic. Up to the moment, the following ones:

- " The culture of the light ". (Elke Patricia Schaffer), where she analyzes the elements of cultural type that affect the system of illumination development.

- "Measurement of the light pollution in natural spaces: Proposal of a predictive model ". (Héctor Solano Lamphar), where it is developed the method of quantification of the explained paragraph 2.b.

It is in steps of presentation:

- " Light pollution: Study of the impact in beaches with marine tortoises nests ". Manolo Blake.

Earning of ending, but in the last phases of development:

- " *Direction of the distribution of the Pollutant flux issued by diverse sources* ". Liliana Fernandez. Development of the Method RAMA - L described, in that the quantification of the EFS is complemented itself with the directional aspects.

B.2 The problematics is not very well known and showed in the different general studies, and only it is approached in Master or specific Post graduate and always in different degree of depth. Often insufficient and of indicated subject matter . They use to be studies of Light Design or Astronomy.

The rest of formative offer are very specific and short courses of specialization. Usually orientated to public already aroused with the problematic.

- Course in Hispanic German Observatory Calar Alto for environmentalists.
- Course interpretation on Regulations of Light Pollution D82/2005 or D357/2010...
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For them the edition of this book is prepared:

LA CONTAMINACIÓN LUMÍNICA.
Una visión desde el foco contaminante:
El alumbrado artificial
Edited: Universidad Politécnica de Catalunya

(THE LIGHT POLLUTION.
A view from the pollutant source:
Artificial lighting)

We will try humbly, that people use as basic bibliography in courses of lighting and astronomic so much schools of Architecture or Engineering and different studies...

c. *Practical Work by students of engineering. Final Degree Projects.*

Often the best way to know a topic is by the practical work or field work. In technical studies, the best way is in the Final Degree Project, which its aim is to condense and to make the acquired knowledge practical, in a concrete project. Nowadays, there are different ones in development, like:

- Method of measurement and map work of the light pollution in nature reserves with difficult access by the SQM-LU.
- System of measurement of the light pollution in a city
- Design of a light system that minimizes the obstructive light, adapted to each project.

4. *Conclusion*

The light pollution is a type of pollution that for his physical characteristics is clearly visible, in effects and in its origins, but it does not create conscience of the importance of its repercussions.

It is created the paradox of the Culture of the Light:

" The same harmful character of the light, between the conscious professionals:

Excess of light is harmful

Between the citizenship it is well valued: > **More light is better. "**

Very opposite that happens with another type of pollution (as atmospheric, acoustic ...), where it is perceived and his pollutant effect is repudiated clearly. And this one is the most important barrier that must break.

From the technical point of view: Its minimization is clearly possible supporting totally the function of the light at night. The market and the technology are ready to do it; but a rejection exists to the measures that minimize its effects, often due to the lack of knowledge of the problem and its repercussions.

By the incorporation of lighting studies to know and to characterize the pollutant source is possible a light project environmentally respectful, energetically efficient and that fulfils the necessary conditions of lighting. But it is necessary to pass from the characterization of the element (lamp, luminary, projector...), to being able to quantify its contribution to the pollution. This is to translate the concept of FHSi to the GRE in a project.

From the citizenship, it enters in discussion. There are actions for elements or interested actors, but it is difficult to support the tension and the raising awareness.

Without the incorporation of the formation and the raising awareness of the quality of the natural environment, the technical actions only will have a social cultural rejection. And this must be the most important area to give priorities. To break the technical barriers to reach those who uses and enjoys the dark and the light: The citizens.

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